Dam Failure

Profiling Hazard Event

> ***Requirement §201.4(c)(2)(i):*** *[The State risk assessment **shall** include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate … .*

Dam failures result from the failure of man made water impoundment structures, which often results from catastrophic down grade flooding. Dam failures are caused by one or a combination of the following: "breach from flooding or overtopping, ground shaking from earthquakes, settlement from liquefaction, slope failure, internal erosion from piping, failure of foundations and abutments, outlet leaks or failures, vegetation and rodents, poor construction, lack of maintenance and repair, misuse, improper operation, terrorism, or a combination of any of these" (Eldredge 46). The Utah State Engineer has been charged with regulating non-federal dams in the State, since 1919. "In the late 1970's Utah started its own Dam Safety Section within the State of Utah Engineers Office to administer all non-federal dams in response to the Federal Dam Safety Act (PL-92-367)" (Eldredge 46).

The State Dam Safety Section has developed a hazard rating system for all non-federal dams in Utah. Downstream uses, the size, height, volume, and incremental risk/damage assessments or dams are all variables used to assign dam hazard ratings in Dam Safety's classification system. Using the hazard ratings systems developed by the Dam Safety Section, dams are placed into one of three classifications high, moderate, and low. Dams receiving a low rating would have insignificant property loss do to dam failure. Moderate hazard dams would cause significant property loss in the event of a breach. High hazard dams would cause a possible loss of life in the event of a rupture. The frequency of dam inspection is designated based on hazard rating with the Division of Water Rights inspecting high-hazard dams annually, moderate hazard dams biannually, and low-hazard dams every five years. Currently, there are a total of 906 dams in Utah, and of those906 dams, 227 have received a high hazard rating by Dam Safety.

The rankings below were compiled as part of a hazard evaluation designed by the Federal Energy Regulatory Commission FERC. The dam rankings are assigned by a priority score with takes into account numerous variables some of which include: public access, population at risk, breach flow, inundation depth, and dam type. The listed ranking shown in Figure I-3 only includes those 50 dams with the highest priority score. This figure lists only the top 50 as priority scores drop dramatically there after. It is also important to note that because another assessment of the dams has not occurred since the previous 2004 state mitigation plan, these rankings have not changed.

Figure I-4

1. Mountain Dell
2. Little Dell
3. Utah Power & Light Cutler
4. Quail Creek
5. Salt Lake County Sugarhouse
6. Logan First Dam
7. Quail Creek South Dam
8. Utah Power & Light Electric Lake
9. Porcupine
10. Red Butte Dam
11. Sevier Bridge
12. Panquitch Lake
13. Sand Hollow North Dam
14. Sand Hollow West Dam
15. North Utah County Tibble Fork
16. Adams
17. Twin Lakes Salt Lake County
18. Settlement Canyon
19. Utah County Thistle Creek Debris
20. DMAD
21. Gunnison Bend
22. Big Sand Wash
23. Kens Lake
24. Piute
25. Smith and Morehouse
26. Millsite
27. Sand H Debris
28. Hobbs
29. Lake Mary-Phoebe
30. Salt Lake County Big Cottonwood Spencer's
31. Haight Creek Lower
32. Provo City-Rock Canyon DB
33. Provo City- Slate Canyon BD No. 3
34. Holmes
35. Huntington
36. Kennecott Mine Bingham Creek
37. Three Creeks- Beaver
38. Davis County-Barton Creek DB
39. Gunlock
40. Lloyds Lake-Monticello
41. Forsyth
42. Blanding City No. 4
43. Utah County-American Fork Debris
44. Kaysville
45. Mill Meadow
46. Grantsville
47. Ash Creek
48. Gunnison
49. Davis County-Stone Creek DB
50. Tony Grove Lake Dam

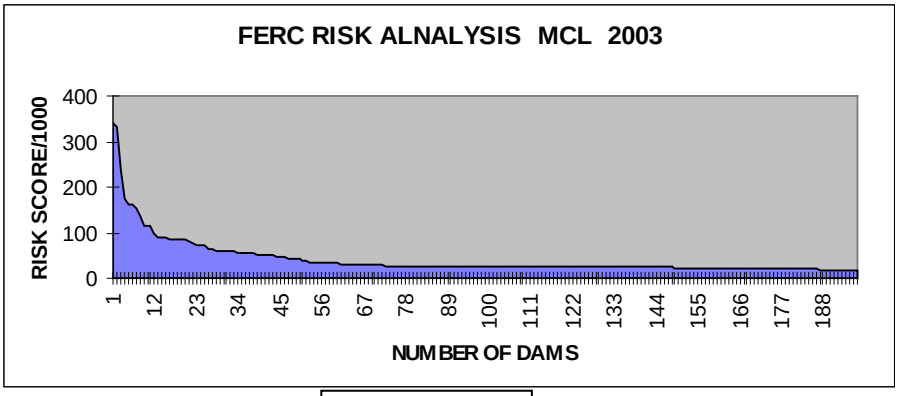

Figure I-5

Significant Dam Failure Events:

Quail Creek
Quail Creek dam failed on New Years Eve 1988 due to extensive foundation seepage. Failure caused approximately $12 million dollars in damage and cost approximately $8 million to rebuild. No lives were lost.

Trial Lake Dam Failure
Trial Lake Dam Failed in 1986 from piping of organics in the foundation contact. The BOR rebuilt the dam and the Corp repaired the damaged river channel

DMAD Dam Failure
DMAD Dam Failed in 1983 and a transient was killed trying to cross the flooding river on a suspended wire. The Gunnison Bend Dam was consequently breached proactively to keep it from overtopping.

Little Deer Creek
Little Deer Creek dam failed on its first filling on June 16, 1963, due to extensive foundation seepage. The catastrophic failure resulted in Utah's first dam failure fatality killing Bradley Galen Brown, a four-year-old boy.

Assessing Vulnerability by Jurisdiction

[Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

Dam-safety and dam construction, although improving, is still and imperfect subjective discipline. Many dams still fail each year in the United States. Society decided long ago the need to store water justified the risk association with storing the water. To assess vulnerability by jurisdiction the total number of dams, classified as having a high hazard rating, in each county were used to rank the jurisdictions vulnerability. Thus, a counties risk is purely a function of the number of high hazard dams in the county. Yet, one should keep in mind many factors, which can cause a dam to fail, and all dams can fail.

Table I-7 Number of Dams with High Hazard Rating per County

Salt Lake	28	Weber	8	Millard	3
Davis	27	Sanpete	7	Juab	2
Utah	22	Emery	6	Tooele	2
Washington	17	San Juan	5	Grand	2
Wasatch	13	Cache	5	Rich	2
Iron	12	Box Elder	5	Daggett	2
Duchesne	10	Beaver	5	Carbon	2
Sevier	9	Piute	4	Wayne	1
Summit	9	Garfield	4	Kane	0
Uintah	8	Morgan	4		
TOTAL	**227**				

Estimating Potential Losses by Jurisdiction

> ***Requirement §201.4(c)(2)(iii):*** *[The State risk assessment **shall** include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.*
>
> ***Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…***

Analyses of the total area per county that is susceptible to dam failure inundation were conducted. High hazard dams and dam inundation area shape files were provided by the AGRC and federal dams and dam indentation area shape files were provided by the Bureau of Reclamation (BOR). The BOR and state dam failure inundation areas were clipped from each county in order to calculate the total area of potential loss per county. The BOR data provides various dam failure scenarios, such as sudden failure and sunny day failure. The highest potential inundation area was used for each listed BOR dam as to prevent overlapping and multiple summations of BOR dam inundation areas. Areas of potential loss due to dam failure inundation for each county were calculated using the "calculate geometry" function in ArcView 9.2

In addition, the percent total potential inundation areas per county were also calculated to demonstrate how much risk due to dam failure inundations exist in each county. This was calculated by dividing the total area of the county by the total potential dam failure inundation area of the county. Maps were then created that visualize this distribution of potential dam failure inundation risk areas per county, and that many of this areas border and intersect population clusters.

Table I-8 Total Potential Dam Failure Inundation per County

County	Total Potential Inundation Area per County (square miles)
Beaver	48.6
Box Elder	79.6
Cache	52.5
Carbon	11.5
Daggett	24.7
Davis	30.6
Duchesne	172.8
Emery	92.7
Garfield	23.9
Grand	17.6
Iron	184.2
Juab	17.9
Kane	0
Millard	560.1
Morgan	62.5
Piute	18.6
Rich	12.4
Salt Lake	49.5
San Juan	5.1
Sanpete	58.5
Sevier	80.9
Summit	44.5
Tooele	67.6
Uintah	488.6
Utah	134.0
Wasatch	34.6
Washington	67.2
Wayne	7.0
Weber	319.3
Total	2767

Table I-9 Total Potential Dam Failure Inundation per County

County	Percent Potential Inundation Area per County (square miles)
Beaver	1.9%
Box Elder	1.2%
Cache	4.5%
Carbon	.8%
Daggett	3.5%
Davis	4.8%
Duchesne	1.6%
Emery	2.1%
Garfield	.5%
Grand	.5%
Iron	5.6%
Juab	.5%
Kane	0%
Millard	8.2%
Morgan	10.3%
Piute	2.4%
Rich	1.1%
Salt Lake	6.1%
San Juan	.1%
Sanpete	3.7%
Sevier	4.2%
Summit	2.4%
Tooele	.9%
Uintah	10.8%
Utah	6.3%
Wasatch	2.9%
Washington	2.8%
Wayne	.3%
Weber	48.4%

The number of people per three arc-seconds within either a high hazard state or federal dam failure inundation area was calculated to help estimate the possible number of people that could be affected by dam failure inundation. Again, the dam data was provided by the AGRC and the BOR and the population density data was provided by LandScan. The Landscan data set was derived by the Oak Ridge National Laboratory utilizing a combination of information such as 2000 census data, proximity of population to roads, slopes, land cover, night-time lights, and other information that is then apportioned to each three second arc-second grid areas. An arc-second is a measure of latitude and longitude used by geographers that equates to approximately 90 meters by 70 meters in area. It is important to note that when working with population density data points, a 90m X 70m resolution is at a finer scale than census block data.

The "select by location" feature found in the ArcView 9.2 software package was used to determine how many people were located within a high hazard dam failure inundation area. LandScan 2005 provided estimated population location data for daytime and nighttime hours. In addition, areas that lie within both state and federal high hazard dam failure inundation areas were identified so that the populations within these overlapping areas were only counted once.

Table I-10 Total Daytime Population at Risk per County

County	Total Daytime Population within High Hazard Dam Failure Inundation Areas
Beaver	979
Box Elder	670
Cache	6724
Carbon	3630
Daggett	0
Davis	1462
Duchesne	35283
Emery	2372
Garfield	138
Grand	2921
Iron	8187
Juab	29
Kane	0
Millard	1534
Morgan	98
Piute	45
Rich	112
Salt Lake	112748
San Juan	11
Sanpete	1954
Sevier	8664
Summit	1430
Tooele	17631
Uintah	1432
Utah	95609
Wasatch	6085
Washington	14255
Wayne	27
Weber	5862

Table I-11 Total Night-time Population at Risk per County

County	Total Night-time Population within High Hazard Dam Failure Inundation Areas
Beaver	1045
Box Elder	1680
Cache	7780
Carbon	4094
Daggett	0
Davis	1462
Duchesne	34801
Emery	2783
Garfield	327
Grand	2516
Iron	10029
Juab	12
Kane	0
Millard	2873
Morgan	168
Piute	214
Rich	242
Salt Lake	100826
San Juan	20
Sanpete	1110
Sevier	9001
Summit	1937
Tooele	18472
Uintah	1145
Utah	92649
Wasatch	5151
Washington	15570
Wayne	76
Weber	3516

Assessing Vulnerability by State Facilities

Requirement §201.4(c)(2)(ii): *[The State risk assessment* ***shall*** *include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State* ***shall*** *describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

State facilities data updated in April 2006 was provided by Utah's AGRC. The data presented in this shape file was complied with the help of several state agencies and state entities. The 2006 state facilities shape file was overlaid on top of the 2006 Utah state dam failure inundation areas map as well as the federal dam failure inundation locations. Using ArcView 9.2, each dam inundation area was clipped from a county shape files for each Utah county. The "select by location" option was then utilized in order to determine how many vulnerable structures exist per county.

Table I-12 Total Number of State Owned Facilities in Dam Failure Inundation Areas

County	Total Vulnerable Structures
Beaver	0
Box Elder	2
Cache	20
Carbon	12
Daggett	4
Davis	53
Duchesne	13
Emery	28
Garfield	3
Grand	23
Iron	39
Juab	5
Kane	0
Millard	2
Morgan	37
Piute	11
Rich	0
Salt Lake	94
San Juan	0
Sanpete	2
Sevier	44

County	Total Vulnerable Structures
Summit	6
Tooele	26
Uintah	17
Utah	212
Wasatch	22
Washington	23
Wayne	0
Weber	92
Total	**790**

Estimating Potential Losses by State Facilities

Requirement §201.4(c)(2)(iii): *[The State risk assessment **shall** include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.*
Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

Values estimating the potential losses by state-owned facilities were calculated by summing the current value of each state-owned facility per county that falls within the county's dam inundation areas. Current values of state facilities per county were provided by the AGRC. It is important to note that the current values represent the total value of the facilities that are located within a dam inundation area. These values assume that in the event of a dam breach, the state facilities within the dam inundation area would be completely destroyed rather than sustaining a particular amount of damage. Therefore, the current values overestimate the damage to state facilities in the event of most dam failures.

Table I-13 Total Value of State Owned Facilities in Dam Failure Inundation Area

County	Total Vulnerable Structures	Current Value
Beaver	0	0
Box Elder	2	0
Cache	20	$32,395,230
Carbon	12	$2,698,359
Daggett	4	$553,100
Davis	53	$198,133,192
Duchesne	13	$18,696,361
Emery	28	$9,575,150
Garfield	3	$338,375
Grand	23	$15,855,858

County	Total Vulnerable Structures	Current Value
Iron	39	$96,716,687
Juab	5	$217,136
Kane	0	0
Millard	2	$922,520
Morgan	37	$16,971,749
Piute	11	$393,354
Rich	0	0
Salt Lake	94	$444,158,000
San Juan	0	0
Sanpete	2	$5,313,400
Sevier	44	$65,731,814
Summit	6	$20,045,857
Tooele	26	$75,648,292
Uintah	17	$20,045,857
Utah	212	$839,614,704
Wasatch	22	$15,750,150
Washington	23	$29,966,603
Wayne	0	0
Weber	92	$120,458,749
Total	**790**	**$2,030,200,497**